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Particulate Measurement - Vehicle Preconditioning

by

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Abstract

A study has been made of the effects of different vehicle preconditioning on particulate emissions from three light-duty diesel automobiles. The results indicate that prior extreme operation of a vehicle can affect the level of particulate emitted during measurements by the Federal Test Procedure. However, one LA-4 driving cycle appears to provide adequate preconditioning for most cases. The duration and magnitude of the preconditioning effect varies among vehicles.

Introduction

In the measurement of emissions from motor vehicles a certain amount of specified vehicle preconditioning operation has been found to be desirable before the standard test is performed. This practice lowers test variability and decreases the possibility of test results being intentionally skewed by extreme operational patterns of the vehicle immediately prior to official measurements. For these reasons it is important that the sensitivity of particulate emission levels to prior vehicle operational patterns be investigated during the development of new test procedures for particulate measurements from light-duty diesel vehicles. Preconditioning operation should be specified as necessary.

Objective

The objectives of this study are:

1. To determine the sensitivity of light-duty diesel particulate emissions to prior preconditioning operation, and
2. to determine the rate at which particulate emissions recover from the influence of prior preconditioning operation.

Test Procedure

Table 1 lists the test sequence followed in this study. The basic philosophy adhered to in choosing the preconditioning cycles was to alternately expose the vehicles to different extremes in vehicle operation, measure the effect on particulate emissions, and observe the rate at which each vehicle returned to a previously established baseline level.



Three available vehicles were selected. The first was an EPA owned 1975 Mercedes 300D diesel automobile for which the particulate baseline was well defined. The second vehicle was a 1977 Cutlass Supreme automobile equipped with a 1978 prototype 350 CID diesel engine, and the third vehicle was a 1978 Peugeot 504 diesel automobile. Particulate baseline emission levels were affirmed for each vehicle before this test series began.

The wide open throttle (WOT) cycle was by far the most severe operation to which the vehicles were exposed. In this cycle wide open throttle accelerations were made from idle to 50 mph followed by closed throttle deceleration to 35 mph, then wide open throttle acceleration to 50 mph followed by closed throttle deceleration to idle. Five of these sequences were considered as one full cycle. As evident in Table 1, three WOT cycles were run on the Mercedes and the Oldsmobile with particulate emissions being collected on each cycle. These vehicles were then preconditioned with one LA-4 cycle followed by emission measurement over the Federal Test Procedure (FTP). Attempts to perform the WOT tests on the Peugeot were abandoned because of a fear of over stress on the vehicle.

Following the WOT runs, six FTP tests were run alternately preconditioning each vehicle with a "blowout" cycle or the New York City (NYC) cycle. The intent in this portion of the study was to alternately expose the vehicle to opposite extremes of preconditioning and observe the influence on particulate emissions. At the end of the test sequence, a final FTP was performed using one LA-4 for preconditioning to determine if the vehicle had return to its original baseline particulate emission level.

The New York City cycle (also known as Sulfate-8) has an average speed of 7.09 mph and a maximum speed of 27.7 mph. This cycle was chosen to represent mild low speed operation with low exhaust flow rates that would tend to accumulate particulate deposits in the engine and exhaust system. Equilibrium conditions were expected to be shifted in the opposite direction during the "blowout" cycle when it was assumed that a relatively high volume of hot exhaust would essentially "blow" particulates out. If trapped particulate was removed, a lower than baseline level of particulate would be emitted during a following FTP because the clean exhaust system would be accumulating part of the particulate emitted by the engine. The blowout cycle chosen was a 50 mph steady cruise condition for 15 minutes with double dynamometer loading and no auxiliary engine cooling fan.

Results

The results of this study are illustrated in Figures 1, 2, 3, and 4. The data presented in Figure 1 were collected while the vehicle operated over the wide-open-throttle cycle. All of the data in Figures 2, 3, and 4 were taken on the LA-4 driving cycle as part of the FTP with different preconditioning as defined in Table 1.

Particulate emission decreased sharply during successive WOT cycle runs (Figure 1) on the Oldsmobile and the Mercedes. WOT tests were not run on the Peugeot. Particulate emissions from the FTP immediately following the WOT runs (Figure 2) were almost identical to the baseline for the Mercedes but the Oldsmobile FTP particulate level was significantly lower than the previously baseline. The next six FTP tests with alternate NYC and blowout preconditioning show random variation near the baseline for the Mercedes and the Peugeot but the Oldsmobile data shows a trend of approaching the baseline with successive tests. The final FTP results (test #8) with LA-4 preconditioning were near the baseline for all three vehicles.

Figure 3 data indicate that the impact of extreme preconditioning operation on subsequent particulate measurements is greater on the cold start test phase than on the hot start. Hot start particulate emission trends are plotted in Figure 4 and are most similar to the weighted FTP data in Figure 2.

Discussion

Of the three vehicles studied, only the Oldsmobile was significantly disturbed by the extreme preconditioning operation. The Mercedes and the Peugeot were influenced, as evidenced by their particulate emission variation outside of normal baseline deviations (Figure 2), but the effects were smaller than expected considering the severity of the preconditioning operation and the possibility of particulate accumulation in the engine and exhaust system. Even after the most extreme WOT operation the Mercedes came back to baseline particulate emissions on the next FTP test with only one LA-4 for preconditioning. Certainly the Mercedes or the Peugeot show no preconditioning effects that indicate a high emission sensitivity that will likely cause emission measurement problems if one LA-4 preconditioning cycle is used.

The Oldsmobile did not come back to the baseline on the next test after the WOT operation. One interpretation of the Oldsmobile results shown in Figure 2 would be that particulate materials were cleaned from the exhaust system by the WOT operation and that equilibrium was being re-established during the subsequent eight tests. Final post-study particulate emissions were back to the original baseline level. It is also possible that the severe WOT operation has an internal effect on the engine and influences particulate emissions through some phenomenon occurring in the combustion chamber. This is less likely than the exhaust system deposition theory.

Preconditioning effects were larger for all vehicles during the cold start portion of the test procedure than during the hot start, possibly because the cold start operation serves as a type of preconditioning operation for the following hot start.

It is reasonable to expect varying influence of preconditioning on particulate emissions from vehicles with different designs of engines, exhaust systems, and ultimately, particulate emission control systems. Such effects are difficult to predict but particulate collectors such as trap oxidizers may show peculiar preconditioning influences and future studies of the type reported here may be necessary as new control technology comes into use.

Conclusions

It is concluded from the results of this study that:

1. The degree to which light-duty diesel particulate emissions are influenced by prior extreme vehicle operation varies among vehicles.
2. Particulate emissions during the cold phase of the test procedure are influenced more by preconditioning operation than are hot emissions.
3. Two out of the three vehicles tested recovered quickly from preconditioning influences and one LA-4 driving cycle is considered to provide adequate preconditioning for particulate measurement procedures.

Table I
Test Sequence

<u>Mercedes 300D</u>	<u>Oldsmobile 350D</u>	<u>Peugeot 504D</u>
WOT*	WOT*	---
WOT*	WOT*	---
WOT*	WOT*	---
LA-4	LA-4	---
FTP*	FTP*	---
NYC	NYC	NYC
FTP*	FTP*	FTP*
Blowout	Blowout	Blowout
FTP*	FTP*	FTP*
NYC	NYC	NYC
FTP*	FTP*	FTP*
Blowout	Blowout	Blowout
FTP*	FTP*	FTP*
NYC	NYC	NYC
FTP*	FTP*	FTP*
Blowout	Blowout	Blowout
FTP*	FTP*	FTP*
LA-4	LA-4	LA-4
FTP*(Post study check) FTP*(Post study check) FTP*(Post study check)		

*Cycles during which particulate material was collected (i.e., sample cycle). All other cycles listed are preconditioned cycles. The dashed lines indicate the minimum 12 hour soak periods.

WOT - Wide Open Throttle
LA-4 - Los Angeles #4
FTP - Federal Test Procedure
NYC - New York City

FIGURE 1

Preconditioning Study
WOT Particulate Emissions

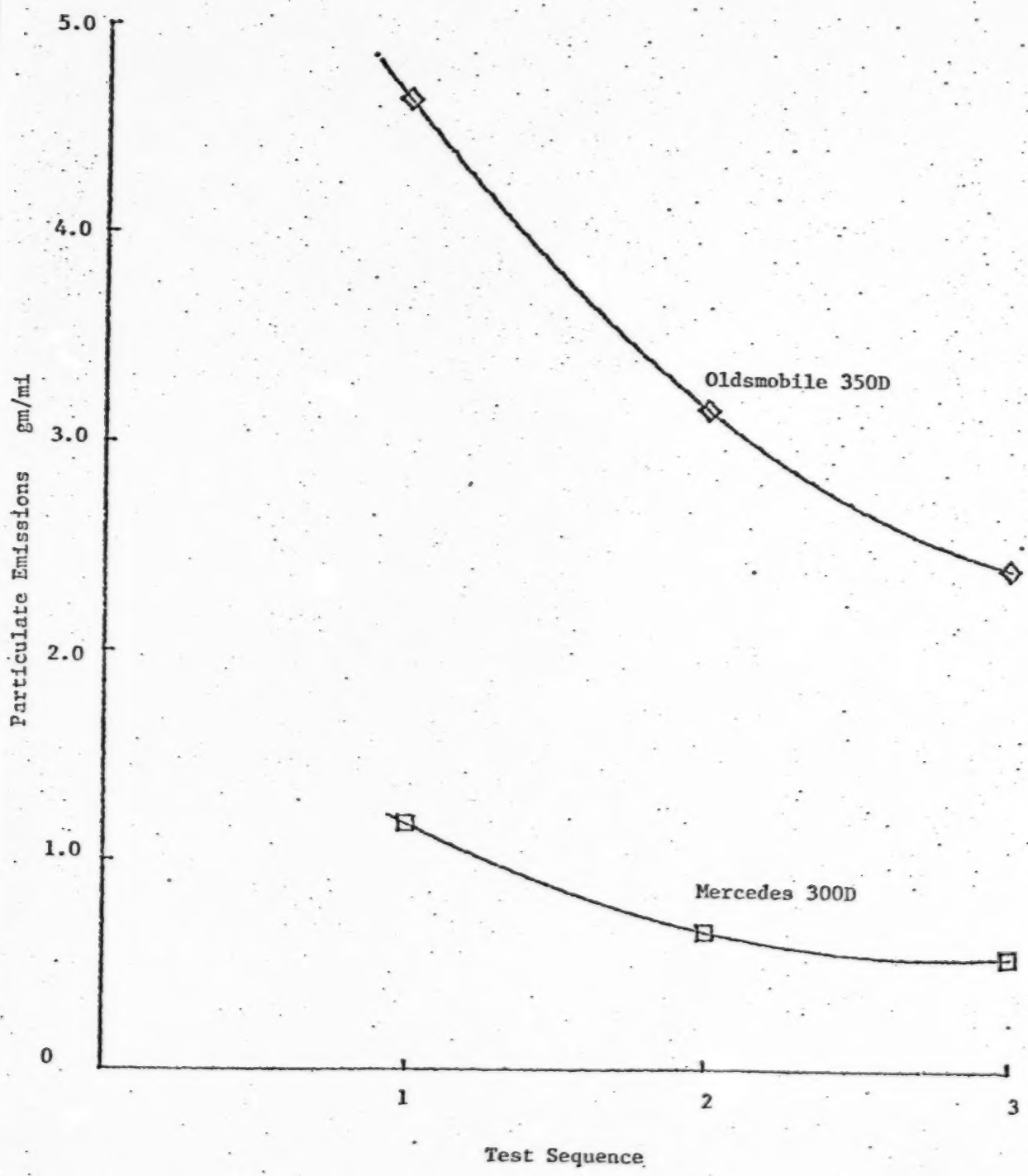


FIGURE 2 |

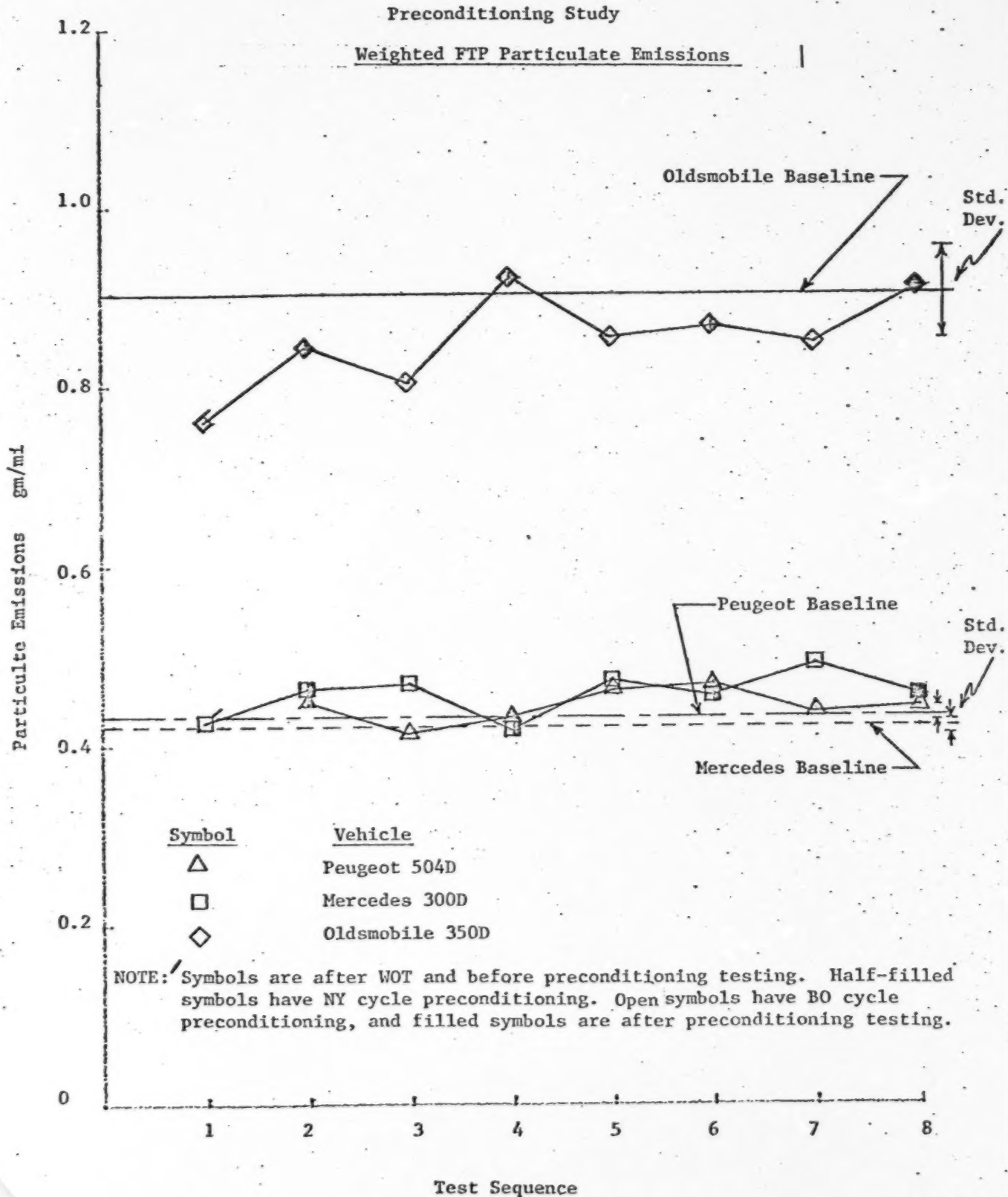


FIGURE 3

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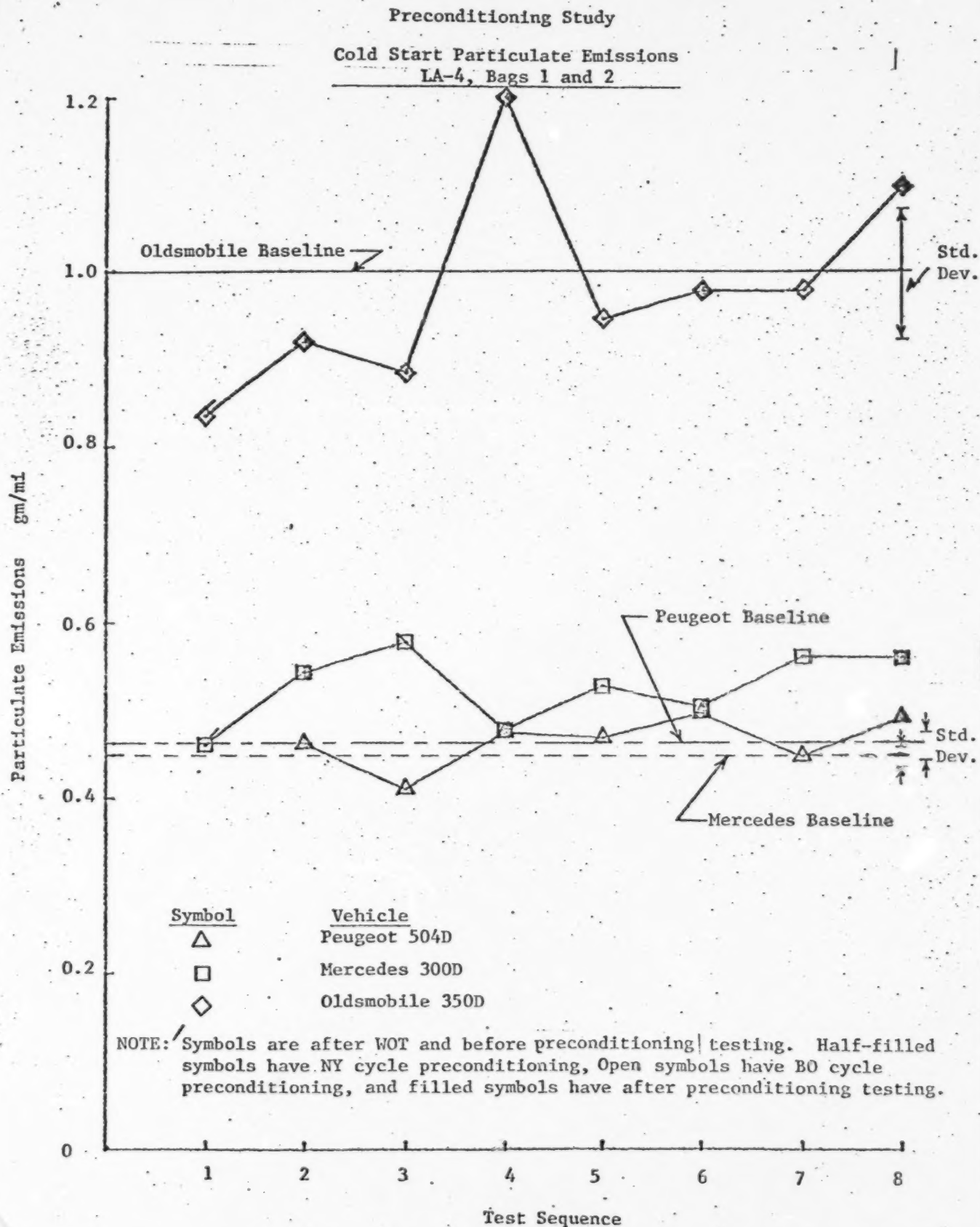


FIGURE 4

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Preconditioning Study

Hot Start Particulate Emissions
LA-4, Bags 3 and 4

